KPR Institute of Engineering and Technology

Learn Beyond

(Autonomous | Affiliated to Anna University)

POSTGRADUATE PROGRAMMES

CURRICULUM AND SYLLABI

PROGRAMME

M.E. | Embedded Systems

REGULATIONS

2026

CONTROLLED COPY

I. Vision and Mission of the Institute

Vision

To become a premier institute of academic excellence by imparting technical, intellectual and professional skills to students for meeting the diverse needs of industry, society, the nation and the world at large

Mission

- Commitment to offer value-based education and enhancement of practical skills
- Continuous assessment of teaching and learning processes through scholarly activities
- Enriching research and innovation activities in collaboration with industry and institutes of repute
- Ensuring the academic processes to uphold culture, ethics and social responsibilities

II. Vision and Mission of the Department

Vision

To be a premier centre for quality education, innovation and research in the field of Electrical and Electronics Engineering to meet the global challenges with professional ethics and social consciousness

Mission

The mission of the department is to

- Provide a holistic environment to students through knowledge-centric and skill-based education
- Collaborate with industries for effective research and innovation in Electrical Engineering and allied areas
- Enable students to serve the society through prolific ideas with professionalism and ethical values

III. Program Educational Objectives (PEOs)

The Program Educational Objectives (PEOs) of the EMBEDDED SYSTEMS (ES) represent major accomplishments that the graduates are expected to achieve after two years of graduation.

PEO1: Apply the acquired knowledge and skills in embedded systems to address complex engineering problems and meet the emerging needs of industry and society

PEO2: Engage in research, innovation, and continuous learning to adapt to emerging technologies in embedded systems and allied areas

PEO3: Demonstrate professional leadership and ethical responsibility in developing innovative, sustainable, and socially relevant embedded system solutions

IV. Program Outcomes (POs)

Graduates of the EMBEDDED SYSTEMS will be able to

PO1: An ability to independently carry out research /investigation and development work to solve practical problems

PO2: An ability to write and present a substantial technical report/document

PO3: An ability to demonstrate a degree of mastery in embedded systems domain

PO4: An ability to use programming languages, professional software, modelling and analysis tools, for design and development of embedded systems

PO5: An ability to apply ethical principles and function effectively as an individual or team to design sustainable, energy-efficient and socially responsible embedded systems

PO6: An ability to develop innovative embedded systems through project management and financial planning, considering socio-economic values

V. PEO / PO Mapping

Following three levels of correlation should be used:

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1: Low

2: Medium

3: High

Particular	PO1	PO2	PO3	PO4	PO5	PO6
PEO 1	3	3	3	3	2	2
PEO 2	3	3	3	3	2	2
PEO 3	2	2	2	2	3	3

VI. Mapping of Course Outcomes (COs) with Program Outcomes (POs)

Sem	Course Title	PO1	PO2	PO3	PO4	PO5	PO6
I	Applied Mathematics for Embedded Applications	✓	✓	✓	-	-	-
	Microcontroller Based System Design	✓	✓	✓	✓	✓	✓
	Embedded Systems Design	✓	✓	✓	✓	✓	✓
	Embedded Programming	✓	✓	✓	✓	✓	✓
	Research Methodology and IPR	✓	✓	-	-	-	✓
	Embedded Systems Design Laboratory	✓	✓	✓	✓	✓	✓

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EMBEDDED SYSTEMS

Regulation 2026

For the students admitted from 2026 onwards

CHOICE BASED CREDIT SYSTEM

CURRICULUM FOR I - IV SEMESTERS

KPR Institute of Engineering and Technology ★ Coimbatore ★ Centre for Academic Courses

SEMESTER I

No	Course Code	Title	Category	Type	L	T	P	J	C
1	P26MA104	Applied Mathematics for Embedded Applications	FC	TwL	2	-	2	-	3
2	P26ES101	Microcontroller Based System Design	PCC	T	3	-	-	-	3
3	P26ES102	Embedded Systems Design	PCC	T	3	-	-	-	3
4	P26ES103	Embedded Programming	PCC	TwL	2	-	2	-	3
5	P26RMC01	Research Methodology and IPR	RMC	T	3	-	-	-	3
6	P26ES104	Embedded Systems Design Laboratory	PCC	L	-	-	4	-	2
7	-	Professional Elective - I	PEC	T	3	-	-	-	3
Total									**20**

T - Theory, **L** - Laboratory, **TwL** - Theory with Laboratory, **TwP** - Theory with Project

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PROFESSIONAL ELECTIVES COURSES (PEC)

SI.NO.	COURSE CODE	COURSE TITLE	CATEGORY	L	T	P	C
1	P26ESP04	Embedded Systems in Smart Grid	PEC	3	0	0	3

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SEMESTER I

		Category: FC				
P26MA104	Applied Mathematics for Embedded Applications	L	T	P	J	C
		2	0	2	0	3

QP PATTERN: B

COURSE OBJECTIVES:

- To introduce linear algebra, state-space representation, and Kalman filtering for control systems
- To develop digital signal processing skills including Z-transform, FFT, filter design, and fixed-point implementation
- To provide knowledge of optimization, probabilistic models, reliability analysis, sensor fusion, and MATLAB-based embedded code generation

COURSE OUTCOMES:

CO 1:	Apply state-space representation, eigenvalue analysis, and matrix factorization for control system analysis using MATLAB	**Apply**
CO 2:	Design and implement digital filters (FIR/IIR) and analyze signals using Z-transform and FFT concepts in MATLAB	**Apply**
CO 3:	Formulate and solve optimization problems in LP, gradient descent, Lagrange multipliers and KKT for resource-constrained systems	**Apply**
CO 4:	Apply probability distributions, Monte Carlo simulation, and Bayesian inference for reliability estimation and sensor fusion	**Apply**
CO 5:	Implement embedded algorithms using MATLAB/Simulink with fixed-point conversion and code generation for ARM/RISC-V targets	**Apply**

CO - PO MAPPING:

Particular	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	3	3	1	-	-	-
CO 2	3	3	1	-	-	-
CO 3	3	2	1	-	-	-
CO 4	3	2	1	-	-	-
CO 5	2	2	1	-	-	-

SYLLABUS:

UNIT I: LINEAR ALGEBRA FOR EMBEDDED SYSTEMS **6 + 6**

State-space representation (states, inputs, outputs) – Eigenvalues and eigenvectors – LU decomposition – QR factorization – Low-rank approximations

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UNIT II: DIGITAL SIGNAL PROCESSING **6 + 6**

Discrete-time signals – Z-transform – FFT algorithms – Digital filter design (FIR, IIR) – Fixed-point implementation – Multirate signal processing

UNIT III: OPTIMIZATION FOR RESOURCE-CONSTRAINED SYSTEMS **6 + 6**

Linear programming – Formulation – Graphical solution – Gradient descent method – Learning rate – Lagrange multipliers – KKT conditions

UNIT IV: PROBABILISTIC MODELS FOR SYSTEMS **6 + 6**

Introduction to Probability distributions – Reliability – Markov chains – Monte Carlo simulation – Bayesian inference for sensor fusion

UNIT V: SIMULATION AND HARDWARE-IN-LOOP VALIDATION **6 + 6**

MATLAB/Simulink for embedded algorithms – Fixed-point vs floating-point simulation – Code generation for ARM/RISC-V using Embedded Coder

LIST OF EXPERIMENTS

1. Linear Algebra for Signal Processing and Control Application: System stability analysis for control systems • Create state-space model using ss function for a simple pendulum • Compute eigenvalues using eig and determine system stability • Perform LU and QR factorization on system matrices using lu and qr
2. Z-Transform and FIR Filter Design Application: Digital filter implementation for signal processing • Compute Z-transform of basic sequences using symbolic math • Design moving average FIR filter using fir1 function • Apply filter to noisy signal using filter command and plot results
3. Linear Programming and Gradient Descent Application: Resource allocation and function minimization • Formulate and solve LP problem using linprog (e.g., product mix) • Implement gradient descent for minimizing $f(x)=x^2$ • Use Lagrange multipliers for constrained optimization with fmincon
4. Monte Carlo Simulation and Bayesian Inference Application: Reliability estimation and sensor fusion • Implement Monte Carlo simulation to estimate system reliability • Generate random samples from probability distributions using rand and normrnd • Apply Bayesian inference for sensor fusion using Bayes' theorem
5. Fixed-Point Simulation and Code Generation Application: Embedded algorithm implementation for ARM • Implement PID controller in Simulink • Convert floating-point model to fixed-point using Fixed-Point Designer • Generate C code for ARM Cortex-M using Embedded Coder

CONTACT PERIODS:

Lecture: 30 Periods **Tutorial:** - Periods **Practical:** 30 Periods **Project:** - Periods **Total:** 60 Periods

TEXTBOOKS:

1. M. Sami Fadali, "Introduction to Random Signals, Estimation Theory, and Kalman Filtering, Springer, 2024
2. John G. Proakis and Dimitris K. Manolakis, "Digital Signal Processing: Principles, Algorithms, and Applications", 4th Edition, Pearson Prentice Hall, 2007

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3. Stephen Boyd and Lieven Vandenberghe, "Convex Optimization", Cambridge University Press, 2004
4. Kishor S. Trivedi, "Probability and Statistics with Reliability, Queuing, and Computer Science Applications", 2nd Edition, Wiley, 2016
5. MathWorks, "Fixed-Point Designer Reference", R2024b, The MathWorks, Inc., 2024

REFERENCES:

1. Gilbert Strang, "Linear Algebra and Its Applications", 5th Edition, Wellesley-Cambridge Press, 1976
2. Hamdy A. Taha, "Operations Research: An Introduction", 10th Edition, Pearson, 2017
3. S. S. Rao, Engineering Optimization: Theory and Practice, 5th Edition, John Wiley & Sons, 2019
4. Josef Hoffmann and Franz, "Quint, Signalverarbeitung mit MATLAB und Simulink", 2nd Edition, Oldenbourg Wissenschaftsverlag, 2012
5. Denić, V., Turkmanović, H., and Popović, I., "Implementation of Extended Kalman Filter for Battery State of Charge Estimation on an Embedded Platform," 2024 32nd Telecommunications Forum (TELFOR), Belgrade, Serbia, 2024, pp. 1-4, doi: 10.1109/TELFOR63250.2024.10819130

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SEMESTER I

		Category: PCC				
P26ES101	Microcontroller Based System Design	L	T	P	J	C
		3	0	0	0	3

QP PATTERN: B

COURSE OBJECTIVES:

- To analyze the architecture, memory organization, and programming of PIC and ARM microcontrollers
- To develop skills in interfacing microcontrollers with peripherals such as ADC, DAC, memory, and communication modules
- To design and implement embedded system applications using PIC and ARM microcontrollers for real-time control

COURSE OUTCOMES:

CO 1:	Analyze PIC and ARM microcontroller instruction set for system design	Analyze
CO 2:	Develop programs using Assembly and C for PIC and ARM microcontroller	Apply
CO 3:	Interface microcontrollers with peripherals such as ADC, DAC, EEPROM, UART, and sensors	Apply
CO 4:	Apply ARM programming concepts including interrupts, timers, and communications	Apply
CO 5:	Design and implement embedded system applications for real-time applications	Apply

CO - PO MAPPING:

Particular	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	3	1	3	2	1	-
CO 2	3	1	3	3	1	-
CO 3	3	1	3	3	2	-
CO 4	3	1	3	3	2	-
CO 5	3	1	3	3	3	1

SYLLABUS:

UNIT I: PIC MICROCONTROLLER 9

PIC18 architecture – Memory organization – Addressing modes – Instruction set – PIC programming in assembly and C – I/O port, data conversion, RAM and ROM allocation, timer programming

UNIT II: ARM ARCHITECTURE 9

Architecture – Register organization– Memory organization – Addressing modes – ARM and instruction set – Thumb instruction set – Registers – Pipeline – Exception and interrupt handling – Coprocessors

UNIT III: PIC PERIPHERAL PROGRAMMING 9

GPIO – Flash and EEPROM memories – Timer – ADC – DAC – Sensor – UART – SPI – I2C Communication – Simple programs

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UNIT IV: ARM PERIPHERAL PROGRAMMING 9

GPIO – Memory – SRAM – FLASH – Timer – UART – SPI – I2C – ADC – DAC – Simple programs

UNIT V: DESIGN WITH PIC AND ARM MICROCONTROLLERS 9

PWM generation – Motor control applications – Sensor based bmbedded systems – Data acquisition systems – Embedded monitoring and control – Industrial automation applications

CONTACT PERIODS:

Lecture: 45 Periods **Tutorial:** - Periods **Practical:** - Periods **Project:** - Periods **Total:** 45 Periods

TEXTBOOKS:

1. Steve Furber, "ARM system on chip architecture", Addision Wesley,2010
2. Andrew N. Sloss, Dominic Symes, Chris Wright, John Rayfield,"ARM System Developer's Guide Designing and Optimizing System Software", Elsevier 2007
3. Muhammad Ali Mazidi, Rolin D. Mckinlay, Danny Causey ,"PIC Microcontroller and Embedded Systems using Assembly and C for PIC18", Pearson Education 2008

REFERENCES:

1. Raj Kamal, "Microcontrollers Architecture, Programming, Interfacing,and System Design", Pearson, 2012
2. ARM Architecture Reference Manual, LPC213x User Manual

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SEMESTER I

		Category: PCC				
P26ES102	Embedded Systems Design	L	T	P	J	C
		3	0	0	0	3

QP PATTERN: C

COURSE OBJECTIVES:

- To provide fundamental knowledge of Embedded Systems architecture, memory organization, and development tools
- To develop understanding of embedded networking, communication and device interfacing
- To impart knowledge on RTOS concepts, hardware/software co-design, and real-time embedded application development

COURSE OUTCOMES:

CO 1:	Apply embedded system architecture, memory hierarchies and development tools to optimize system performance	Apply
CO 2:	Apply embedded communication protocols for processor based networking	Apply
CO 3:	Analyze RTOS scheduling, synchronization techniques, and schedulability in real time systems	Analyze
CO 4:	Design embedded systems using hardware/software co-design approaches and UML modeling	Apply
CO 5:	Develop intelligent and secure embedded applications for real-world systems	Apply

CO - PO MAPPING:

Particular	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	3	1	3	2	2	-
CO 2	2	1	3	-	2	-
CO 3	3	1	3	3	2	-
CO 4	2	1	3	3	3	-
CO 5	2	1	3	3	3	1

SYLLABUS:

UNIT I: EMBEDDED SYSTEM ARCHITECTURE 9

Embedded SoC concepts – interrupt and exception handling – Memory hierarchy – cache organization – Embedded development environment – cross compilation – debugging – JTAG/SWD – performance and resource analysis.

UNIT II: EMBEDDED COMMUNICATION 9

Embedded ethernet and wireless connectivity – Wi-Fi, Bluetooth low energy and LoRa based communication - IoT communication protocols – MQTT, CoAP – Device to device and device to cloud communication

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UNIT III: RTOS BASED EMBEDDED SYSTEM DESIGN 9

RTOS architecture – Real time task models – Threads and processes – Task states – Context switching – Interrupt handling – Response time and deadline analysis – Deterministic real time behavior – Scheduling algorithms – Schedulability analysis – Interrupt latency – Jitter – Worst case execution time

UNIT IV: HARDWARE/SOFTWARE CO-DESIGN 9

Embedded system modeling – UML/SysML – system specification – hardware/software partitioning and codesign – hardware acceleration – device drivers – Software in the Loop and Hardware in the Loop testing

UNIT V: INTELLIGENT AND SECURE EMBEDDED SYSTEM 9

Low power design – Embedded security – Secure boot and firmware protection - Edge Computing, TinyML and Edge AI for embedded systems - Case studies: automotive systems, industrial automation, predictive maintenance

CONTACT PERIODS:

Lecture: 45 Periods **Tutorial:** - Periods **Practical:** - Periods **Project:** - Periods **Total:** 45 Periods

TEXTBOOKS:

1. Jane W. S. Liu, "Real-Time Systems", Pearson Education, 2000
2. Giorgio C. Buttazzo, "Hard Real-Time Computing Systems: Predictable Scheduling Algorithms and Applications", 3rd Edition, Springer, 2011
3. Qing Li and Caroline Yao, "Real-Time Concepts for Embedded Systems", CMP Books, 2003

REFERENCES:

1. Hermann Kopetz, "Real-Time Systems: Design Principles for Distributed Embedded Applications", 2nd Edition, Springer, 2011
2. Phillip A. Laplante, "Real-Time Systems Design and Analysis", 4th Edition, Wiley-IEEE Press, 2011
3. Jean J. Labrosse, "Embedded Systems Building Blocks", 2nd Edition, CMP Books, 2000

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SEMESTER I

		Category: PCC				
P26ES103	Embedded Programming	L	T	P	J	C
		2	0	2	0	3

QP PATTERN: B

COURSE OBJECTIVES:

- To develop fundamental programming skills in C programming, including functions, arrays, structures, pointers, and memory allocation
- To familiarize with Embedded C, Linux programming tool-chain, and Python programming for embedded software development
- To develop practical skills in debugging, testing, profiling, and optimization of embedded software

COURSE OUTCOMES:

CO 1:	Apply C programming concepts including functions, arrays, structures, pointers, and memory allocation to develop structured programs	**Apply**
CO 2:	Apply Embedded C programming techniques to implement hardware delays and timeout mechanisms for real-time applications	**Apply**
CO 3:	Analyze the stages of C compilation and utilize GCC, GDB, Make, and GNU binary utilities in Linux-based software development	**Analyze**
CO 4:	Apply Python programming and relevant libraries for mathematical computation, numerical plotting, GUI, imaging, and networking applications	**Apply**
CO 5:	Analyze embedded software using coding standards, debugging, testing, profiling, and performance and power optimization techniques	**Analyze**

CO - PO MAPPING:

Particular	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	3	1	2	2	-	-
CO 2	3	1	3	3	2	-
CO 3	3	1	2	3	3	-
CO 4	2	1	2	2	2	-
CO 5	2	1	3	3	3	1

SYLLABUS:

UNIT I: FUNDAMENTALS OF C PROGRAMMING CONCEPTS **6 + 6**

Typical C program development environment – Structured program – Development in C – Data types and operators – C program control – C functions – Arrays – Structure and union – Pointer – Static and dynamic memory allocation – Linked list

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UNIT II: EMBEDDED C **6 + 6**

Adding structure to 'C' code: object oriented programming with C – Header files for project and port – Examples – Meeting real time constraints: Creating hardware delays – Need for timeout mechanism –Creating loop timeouts – Creating hardware timeout

UNIT III: C PROGRAMMING TOOL CHAIN IN LINUX **6 + 6**

C preprocessor – Stages of compilation – Introduction to GCC – Debugging with GDB – Make utility – GNU configure and build system – GNU binary utilities – Profiling – using gprof – GNU C library

UNIT IV: PYTHON PROGRAMMING **6 + 6**

Data types – Control flow statements – Functions – Library for mathematical functionalities and tools – Numerical plotting library – GUI libraries for python – Imaging libraries for python – Networking libraries

UNIT V: DEBUGGING AND OPTIMIZATION **6 + 6**

ANSI C – C89, C95, C99, MISRA C – Debugging techniques –Testing methods – Code profiling – Performance and power optimization1. Implement functions, arrays, structures, unions, pointers in C and dynamic memory allocation

LIST OF EXPERIMENTS

1. Implement functions, arrays, structures, unions, pointers in C and dynamic memory allocation
2. Create and use header files for multi file C programs
3. Implement delay generation and timeout mechanisms in embedded C
4. Compile C programs using GCC and study different stages of compilation
5. Develop and execute make files for multi file C projects
6. Data analytics using pandas and NumPy

CONTACT PERIODS:

Lecture: 30 Periods **Tutorial:** - Periods **Practical:** 30 Periods **Project:** - Periods **Total:** 60 Periods

TEXTBOOKS:

1. Brian W. Kernighan and Dennis M. Ritchie, "The C Programming Language", 2nd Edition, Prentice Hall, 2015
2. Michael J. Pont, Embedded C, 2nd Edition, Pearson Education, 2002

REFERENCES:

1. Reema Thareja, "Python Programming", 3rd Edition, Oxford University Press, 2025
2. Richard Petersen,"Linux: The Complete Reference", 6th Edition, McGraw–Hill Education, 2017
3. https://misra.org.uk/publications/

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SEMESTER I

		Category: RMC				
P26RMC01	Research Methodology and IPR (Common to CAD, DS, ES, PCS, PHDCE, PHDIC, PHDME, PHDSH, SE, VL)	L	T	P	J	C
		3	0	0	0	3

QP PATTERN: B

COURSE OBJECTIVES:

- To impart knowledge in problem formulation, analysis and solutions
- To impart skills required for technical paper writing / presentation without violating professional ethics
- To familiarize knowledge on patent drafting and filing patents

COURSE OUTCOMES:

CO 1: Apply the principles of research problem formulation to identify, define, and investigate engineering research problems using appropriate data collection and analysis techniques — **Apply**

CO 2: Analyze research literature, data collection methods, research ethics, and plagiarism issues to identify research gaps and select suitable methodologies — **Analyze**

CO 3: Evaluate the quality of technical reports, research papers, and research proposals by applying standard scientific writing and presentation practice — **Evaluate**

CO 4: Apply the principles and procedures of Intellectual Property Rights (IPR), including patents, patent filing, and international patenting systems, to protect technological innovation — **Apply**

CO 5: Evaluate patent rights, technology transfer mechanisms, patent databases, geographical indications, and emerging developments in Intellectual Property Rights for engineering and research applications — **Evaluate**

CO - PO MAPPING:

Particular	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	3	-	-	-	-	-
CO 2	3	-	-	-	-	-
CO 3	3	3	-	-	-	-
CO 4	-	3	-	-	-	2
CO 5	-	3	-	-	-	2

SYLLABUS:

UNIT I: RESEARCH PROBLEM FORMULATION — 9

Meaning of research problem – Sources of research problem – Criteria characteristics of a good research problem – Errors in selecting a research problem – Scope and objectives of research problem. Approaches of investigation of solutions for research problem – Data collection – Analysis – Interpretation – Necessary instrumentations

UNIT II: LITERATURE REVIEW AND DATA COLLECTION — 9

Effective literature studies approaches – Analysis – Plagiarism and research ethics. Method of data collection – Types of data – Primary Data – Scales of measurement – Source and collection of data observation method – Secondary data

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UNIT III: TECHNICAL WRITING / PRESENTATION 9

Effective technical writing: How to write report – Paper – Developing a research proposal – Format of research proposal – Presentation and assessment by a review committee

UNIT IV: INTRODUCTION TO INTELLECTUALPROPERTY RIGHTS 9

Nature of Intellectual Property: Patents – Designs – Trade and Copyright. Process of Patenting and Development – technological research – Innovation – Patenting – Development – International Scenario – International cooperation on Intellectual Property – Procedure for grants of patents – Patenting under PCT

UNIT V: INTELLECTUAL PROPERTYRIGHTS 9

Patent Rights: Scope of Patent Rights – Licensing and transfer of technology – Patent information and databases – Geographical Indications – New Developments in IPR – Administration of Patent System – IPR of Biological Systems – Computer Software etc.

CONTACT PERIODS:

Lecture: 45 Periods **Tutorial:** - Periods **Practical:** - Periods **Project:** - Periods **Total:** 45 Periods

REFERENCES:

1. Cooper, DR and Schindler, P S., "Business Research Methods", 9th edition, Tata McGraw Hill, 2014
2. Robert P.Merges, Peter S, Menell, Mark A.Lemley, "Intellectual Property in New Technological age", Volume I, Clause 8 Publishing,2022
3. Ranjit Kumar, "Research Methodology: A Step by Step Guide for beginners", 3rd edition, Sage Publications,2010

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SEMESTER I

		Category: PCC				
P26ES104	Embedded Systems Design Laboratory	L	T	P	J	C
		0	0	4	0	2

QP PATTERN: B

COURSE OBJECTIVES:

- To familiarize with embedded development environments, microcontroller programming, debugging, and hardware interfacing
- To develop practical skills in GPIO, timers, interrupts, serial communication, ADC, PWM, and digital communication protocols
- To enable the design and development of mini embedded systems by integrating microcontroller peripherals, sensors, actuators, and communication interfaces using Embedded C

COURSE OUTCOMES:

CO 1:	Configure and utilize embedded development tools including IDE, compiler, debugger, flash programmer, and target boards for embedded system development	Apply
CO 2:	Analyze the operation of GPIO, timers, counters, and interrupt mechanisms in embedded application	Analyze
CO 3:	Analyze UART, ADC, PWM, and I²C/SPI communication techniques for embedded applications	Analyze
CO 4:	Evaluate suitable sensors, actuators, and communication interfaces for specific embedded control applications	Evaluate
CO 5:	Design and develop a mini embedded system by integrating GPIO, timers, UART, sensors, and actuators using Embedded C	Create

CO - PO MAPPING:

Particular	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	3	2	2	3	3	-
CO 2	2	2	2	2	3	-
CO 3	2	2	2	3	3	-
CO 4	2	2	3	3	3	3
CO 5	3	3	3	3	3	2

SYLLABUS:

LIST OF EXPERIMENTS

1. Installation and configuration of embedded development environment (IDE, compiler, debugger, flash programmer, target board setup, build and debug process)
2. GPIO programming – LED blinking, push button, interface and external interrupt
3. Timer and counter applications – Periodic interrupts, delay generation and event counting
4. Interrupt programming – external and timer interrupt handling
5. UART serial communication – transmit and receive data between microcontroller and PC
6. ADC and sensor interfacing – Read analog sensor values and display/transmit data

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7. PWM signal generation – LED brightness control or servo motor control
8. Digital sensor interfacing using I²C/SPI protocol (temperature, accelerometer, EEPROM, and etc.)
9. DC motor/stepper motor control using PWM and direction control
10. Mini embedded system development using embedded C (register level programming integrating GPIO, timer, UART and sensor Interface)
11. Prototype

CONTACT PERIODS:

Lecture: - Periods **Tutorial:** - Periods **Practical:** 60 Periods **Project:** - Periods **Total:** 60 Periods

REFERENCES:

1. Jonathan W. Valvano, "Embedded Systems: Real-Time Interfacing to ARM Cortex-M Microcontrollers", 3rd Edition, Cengage Learning, 2017
2. Michael J. Pont, "Embedded C", 2nd Edition, Pearson Education, 2008

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PROFESSIONAL ELECTIVE COURSES

		Category: PEC				
P26ESP04	Embedded Systems in Smart Grid	L	T	P	J	C
		3	0	0	0	3

QP PATTERN: B

COURSE OBJECTIVES:

- To impart comprehensive knowledge of smart grid architecture, standards, and the integration of embedded systems in modern power networks
- To develop expertise in embedded sensing, real-time monitoring, communication technologies, and distributed control for smart grid applications
- To enable the design, optimization, and secure implementation of intelligent embedded solutions for energy management and next-generation smart grid systems

COURSE OUTCOMES:

CO 1:	Implement smart grid architectures, standards, embedded processors, and real-time operating systems for modeling modern power networks and cyber-physical systems	**Apply**
CO 2:	Utilize embedded sensing, synchrophasor measurement, real-time data acquisition, and synchronization techniques for smart grid monitoring applications	**Apply**
CO 3:	Apply IoT, smart grid communication protocols, edge/cloud computing, and real-time processing techniques for smart grid monitoring and energy management	**Apply**
CO 4:	Examine energy management, optimization, demand response, forecasting, cybersecurity, and secure embedded architectures for smart grid applications	**Analyze**
CO 5:	Investigate emerging embedded smart grid technologies, including AI, TinyML, blockchain, digital twins, predictive maintenance, electric vehicle integration, and microgrid applications	**Analyze**

CO - PO MAPPING:

Particular	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	3	1	2	1	1	-
CO 2	2	1	2	1	1	-
CO 3	2	1	3	1	1	-
CO 4	2	1	3	1	1	-
CO 5	2	1	2	1	1	-

SYLLABUS:

UNIT I: SMART GRID ARCHITECTURE AND MODELING 9

Limitations of conventional grids – Smart grid evolution – Hierarchical and layered architectures – Smart grid standards (IEC 61850, IEEE 1547) – Embedded processors (ARM Cortex-M, ESP32, STM32) – Real time operating systems – Modeling of power systems with embedded controllers – Cyber physical system modeling

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UNIT II: EMBEDDED SENSING, MONITORING AND SYNCHRONIZATION 9

Embedded sensing fundamentals: voltage, current and power sensors – Smart energy meters – Phasor measurement units and synchrophasor estimation – Embedded data acquisition systems – Real-time signal processing – GPS synchronization – Wide area measurement systems

UNIT III: SMART GRID COMMUNICATION AND EDGE COMPUTING 9

Need for communication in smart grids – Internet of things in smart grid – Machine-to-machine communication – MQTT, OPC UA, IEC 61850 GOOSE protocols – Cloud and edge computing concepts – Cloud integration – Latency, bandwidth, QoS analysis – Interoperability challenges

UNIT IV: ENERGY MANAGEMENT AND CYBER SECURITY 9

Energy management systems– Optimization techniques (linear programming, evolutionary algorithms) – Demand response and load forecasting – Cybersecurity requirements – Secure embedded architecture – Encryption and authentication – Secure firmware update – Intrusion detection

UNIT V: EMERGING TRENDS IN SMART GRIDS 9

Need for cybersecurity in smart grids – Blockchain in smart grid – Artificial Intelligence in embedded smart grid – TinyML – Predictive maintenance – Digital Twin – Electric vehicle integration – Smart cities integration – Case studies on embedded smart grid applications

CONTACT PERIODS:

Lecture: 45 Periods **Tutorial:** - Periods **Practical:** - Periods **Project:** - Periods **Total:** 45 Periods

TEXTBOOKS:

1. James Momoh, "Smart Grid: Fundamentals of Design and Analysis", Wiley, 2012
2. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, "Smart Grid: Technology and Applications", Wiley, 2012

REFERENCES:

1. Stuart Borlase, "Smart Grids: Infrastructure, Technology and Solutions", 3rd Edition, CRC Press Taylor and Francis, 2022
2. Raj Kamal, "Embedded Systems: Architecture, Programming and Design", 4th Edition, McGraw-Hill Education India, 2021
3. Shanthi Pavan, "Embedded Systems Design using ARM Cortex-M Microcontrollers", 2nd Edition, McGraw-Hill Education India, 2023
4. C L Wadhwa, "Electric Power Systems", New Age International, 2014

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